BBN TECHNOLOGIES
A Verizon Company

DARWARS Integration Plan

A BBN Technologies Document

Version 2.0

31 January 2005

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Contents

1 Overview

U.S. military personnel who emerge from the Combat Training Centers (CTC) are the best trained in the world. DARWARS aims to bring the level of excellence achieved at the CTCs to all our forces, all the time, everywhere. DARWARS will support U.S. forces in achieving and sustaining a level of training readiness that now only some achieve, and only immediately after the best human-run training exercises. In the DARWARS vision, current personal computer technology, bolstered by the commercial successes of the massively multiplayer game market, will support a revolution in computer-based training and in the way that individuals incorporate training into their lives.

BBN will achieve this vision with the creation of DARWorld – an innovative training environment that serves multiple member communities: trainers, trainees, subject matter experts, developers, administrators, *etc*. DARWorld can be viewed as a vast repository of rich, immersive, interactive training experiences for individuals, teams and teams of teams. These experiences are created, organized, accessed, advertised, populated, staged, and reviewed through a family of web-enabled services provided within DARWorld. DARWorld associates these experiences with training objectives for individuals and teams, the knowledge and skills that underlie the objectives, and in turn their ties to specific situations and events that can arise within a training session. DARWorld enhances the instructional value of distributed simulation-based training by directing its users to relevant training experiences; minimizing administrative overhead and maximizing instructional impact through distributed access to human and computer-based expertise, matching users to appropriate roles, reviewing what happened anytime after an event, and sharing these observations with others. As an inhabitant of DARWorld, your identity, preferences, competencies, learning goals, plans, schedules, affiliations, and history persist and are available from anywhere on the network. You are not alone in DARWorld – an array of collaboration tools supports establishing and maintaining the social and working relationships that characterize effective teams and organizations.

DARWorld is fundamentally distributed and network-centric, and so becomes the natural proving ground for a transformation in training. It is a tool for exploring and understanding what needs to be learned by the next generation of warfighters, and then crafting and delivering those experiences on demand to those who need them, when they need them.

This integration plan was initially described as follows (in our base SOW):

> "lays out a roadmap for implementing the architecture, extending its capabilities over time, incorporating the LMTSs, and interfacing with other simulations. The plan will include recommendations for participation in the proposed integration process;"

This Integration Plan lays out a roadmap for implementing the DARWARS vision as follows. In Section 2, we present the DARWARS vision in more detail. Section 3 presents the features of the DARWorld architecture that implement this vision. In Section 4 we present a plan for achieving DARWorld: building the infrastructure and integrating program-supported and other training systems. Section 5 presents our actions and thoughts on transitioning the DARWARS program from DARPA to the Services and beyond. This transition plan is carried out in parallel with the technical design and implementation detailed in the other sections.

Version 1.0 of this Integration Plan was the initial release and detailed plans for the project after the initial base competition phase. The current document updates that release as of the end of BBN's Option 1 – with progress to date and plans going forward as of January 2005.

2 The Path to DARWARS

2.1 The DARWARS Vision

DARWARS can spark a revolution in military training by bringing the creation and delivery of training closer to the end users, enabling rapid authoring and distribution, and allowing users to focus on having effective training experiences unencumbered by concerns of software distribution, resource marshalling, and team scheduling.

DARWARS will allow our military to acquire and maintain combat readiness and proficiency by focusing on the following basic goals:

- Universal Access to Training – DARWARS training will be available to all our forces, all the time, wherever they are located. By virtue of being continuously available on demand, DARWARS training will insure that skills achieved in training are retained. DARWARS training will focus on training at all levels: individuals, teams, and teams of teams. Experiences in DARWARS will be preserved over time, thus providing a persistent identity for individuals and groups, and their history of involvement with the training environment.
- Increased Training Effectiveness – DARWARS will create a fundamentally richer relationship between trainee and computer through Last Meter Training Systems (LMTSs). Instruction from automated tutors, combined with a rich practice environment, has been shown to produce up to a two-sigma increase in performance. Coupled with reachback to human instructors and support for community-wide after action review, the LMTS insures that trainees receive relevant practice with feedback that is the hallmark of effective training. Borrowing practices from the best on-line gaming environments, DARWARS aims to provide a compelling training experience to fully engage learners.
- Reduced Training Development Costs – DARWARS will develop tools and components for building Training Systems and a supportive infrastructure of web services in which to embed them. Borrowing practices from the gaming community,

DARWARS will seek to involve users in the authoring process, so that new elements can be added with ease, and training can be rapidly tailored and adapted to meet the emerging challenges of modern conflicts.

2.2 From Vision to Reality

There is a confluence of forces that we believe can be focused on this vision to make it a reality, as illustrated in Figure 2-1. The need is clear: joint readiness, which includes the ability to work effectively in combination with coalition forces and other less formal alliances, is key to success in future conflicts. It demands training that focuses on teams – and teams of teams; that scales up to large numbers of participants; that is readily available to learners without extensive advance coordination, administration, or travel; that is deployable; and that can be adapted in the field to reflect novel and unexpected situations.

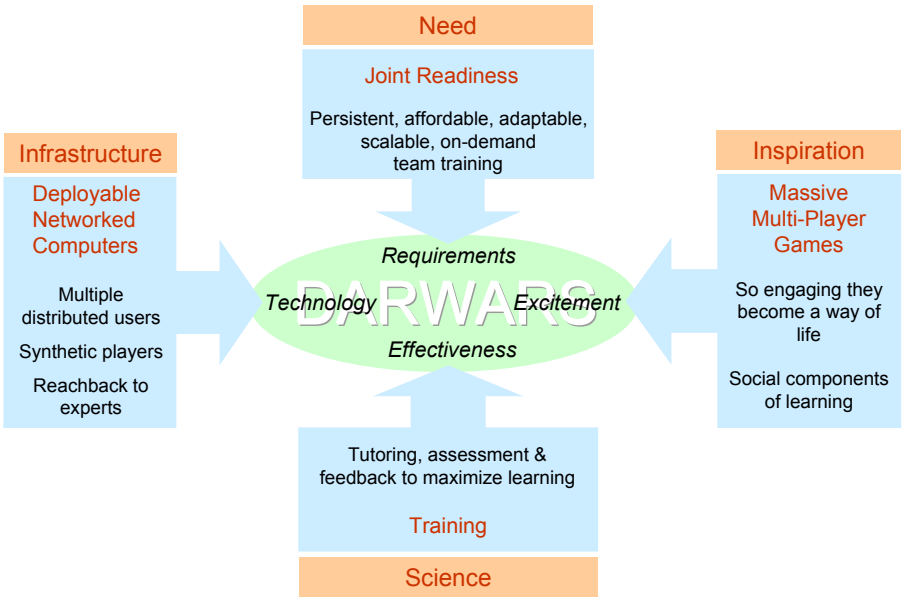

Figure 2-1: DARWARS Influences

The infrastructure for administering and deploying distributed systems is increasingly available to support networked users in coordinated exercises and access to expertise from remote sites. The increasing emphasis on network-centric warfare reflects this same belief in the importance of taking full advantage of networks – both computer and social – in how we fight and therefore in how we must train. Advances in human behavior modeling lend another pillar to the infrastructure upon which DARWARS will be built. Mixing synthetic with human players allows for larger exercises, eases the task of scheduling and populating an exercise, and allows for more control over the instructional goals of the exercise.The commercial game community in general, and massive multiplayer games in particular, lend inspiration as well as development and delivery tools to help realize the DARWARS vision. They also inform the design of the learning experiences available in DARWARS by emphasizing the importance of engaging content to draw learners into the excitement of DARWARS. The gaming culture has also made

evident the vital contributions of social interaction among players, and its contribution to a feeling of involvement and to learning.

Intelligent tutoring systems – part of the LMTS – take DARWARS beyond being a source of practice by insuring that a user's experiences in DARWARS are created, guided and supported with training goals foremost in mind. They contribute assessment and instructional feedback during and after an exercise that drives learning forward, and supplement human instructors, who may not always be available to a learner. Delivering suitable feedback and assessment to teams as well as individual participants is an important goal for DARWARS.

Some Basic DARWARS Tenets

In considering how to make DARWARS a reality, we have retained the basic tenets that were part of the early descriptions of DARWARS, while adapting and refining them as part of putting together a coherent, responsive, and achievable plan.

• *Universal* – access by individuals, teams, and teams of teams, including perhaps hundreds of players, working across echelons. We do not expect to scale up to thousands of players *in the same virtual world* since this scale is not currently being achieved even in the largest on-line game environments.

• *Continuous and Persistent* – a continuously available source of learning experiences for everyone whenever they seek it. DARWARS will be a source of experiences on-demand and tailored for your team's benefit, rather than a universal "virtual war" that one joins in progress but that may not provide the level of instructional value needed at any point in time. Nothing precludes staging long-running conflicts where the consequences of one's actions play out over extended periods of time, but this is just one type of available experience. The real value of persistence is in the recording of ones' experiences and competencies – to be known by DARWARS – and the ability to use that knowledge to guide choices for future learning experiences. We see great value in allowing different LMTSs to reference and update a common repository of user data.

• *On-demand* – deployable and readily available at the convenience of the learner. Deployable means more than small in size and modest in resource use; it also entails being easy to configure, network, and maintain; and it means retaining access to instructionally valuable sources of feedback and assessment. In DARWARS, one can't assume the availability of instructors, system administrators, or fellow players. Assembling teams and staging events should be facilitated by DARWARS.

• *Engaging* – Learners want to use DARWARS because they can find and initiate activities that are compelling and valuable to them. One elects to use DARWARS because it furthers one's learning goals and prepares one for upcoming real-world missions. DARWARS is primarily an immersive team environment for acquiring and applying skills in appropriately realistic settings. DARWARS supports communities of learners, instructors, and administrators through a family of social interaction tools.

DARWARS encourages users to contribute to the development of content based on their own needs and real-world experiences.

• *Effective* – training that works, that produces measurable performance improvements in actual missions. DARWARS organizes users and experiences against a backdrop of learning objectives, skills, knowledge, and situations that together work to provide *relevant* practice and *individualized* feedback.

2.3 The Role of the Training System in DARWARS

The Training System (TS)[1] is central to our DARWARS Vision. In addition to providing the ability to act within a suitably realistic virtual world, the TSs are repositories of domain specific knowledge, skills, and instructional expertise that are the distinguishing features of DARWorld. DARWorld content derives from assemblies of TSs that are packaged to deliver effective training. There is value in integrating existing TSs and in developing new ones for additional skills. Figure 2-2 illustrates the principal functional components of the typical TS. We have found this three-part decomposition useful in characterizing different TSs and in thinking more clearly about how TSs can be combined and reused.

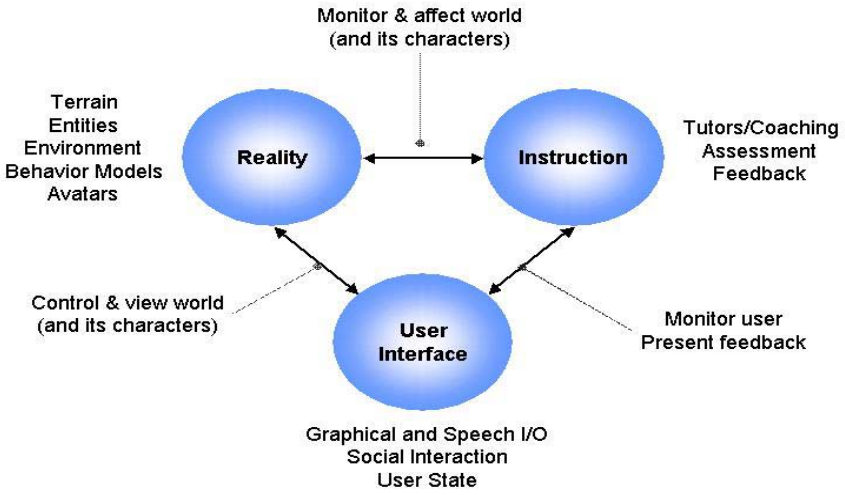

Figure 2-2: Training System Functional Components

We will integrate Training Systems into DARWorld at varying levels at various times. For example, current integrations are at a launch level in that the training system is defined in a Package (with objectives) launched from a command line. "Higher" levels

[1] Initially called Last Meter Training System (LMTS) we found that the Last Meter designation was confusing to readers who are not DARWARS performers so dropped the LM for clarity.

of integration would include, for example, communicating training result information to DARWARS (and thus potentially to other systems) via training profiles. The roadmap for integration (Section 4) includes more detail about integration accomplished and suggests several other examples of possible TS integrations.

The offer to contribute instructional content and make training games and simulations available within DARWorld is one of the attractions we will offer in our effort to forge alliances with potential DARWARS partners. Early integration of Training Systems has two main benefits: it demonstrates the value and importance of delivering instruction within DARWorld, and it drives the development of DARWorld services with concrete examples rather than abstract ruminations.

Training Systems are also valuable as sources of reusable tools and components from which additional Training Systems can be forged. Our ongoing interaction with existing Training System developers has exposed several software modules that would be generally valuable to future TS developers. We will coordinate the definition and distribution of these components as part of our integration process. As the locus of instructional expertise in DARWorld, Training Systems are central to our vision of how training scales to larger teams and more varied scenarios. A discussion of Training System cooperation appears in the Architecture section 3.8, which also summarizes the services and interfaces provided by DARWorld to the Training System.

2.4 Training in DARWARS

DARWorld is home to a spectrum of training as shown in Figure 2-3. It spans training focused on acquiring individual skills through demonstrating those skills in a variety of contexts including large-scale joint operations. Likewise, it spans training targeting a single user as well as medium scale team training and large scale teams of teams. Since the currently constituted DARWARS program does not incorporate a massive multiplayer Training System, we have made that a priority in our transition plan, to insure that this end of the training spectrum is represented. We feel that the team-training issues, as well as the simulation and architecture issues, that emerge at this scale may require qualitatively different and novel approaches, which promise to become a major contribution of the DARWARS program.

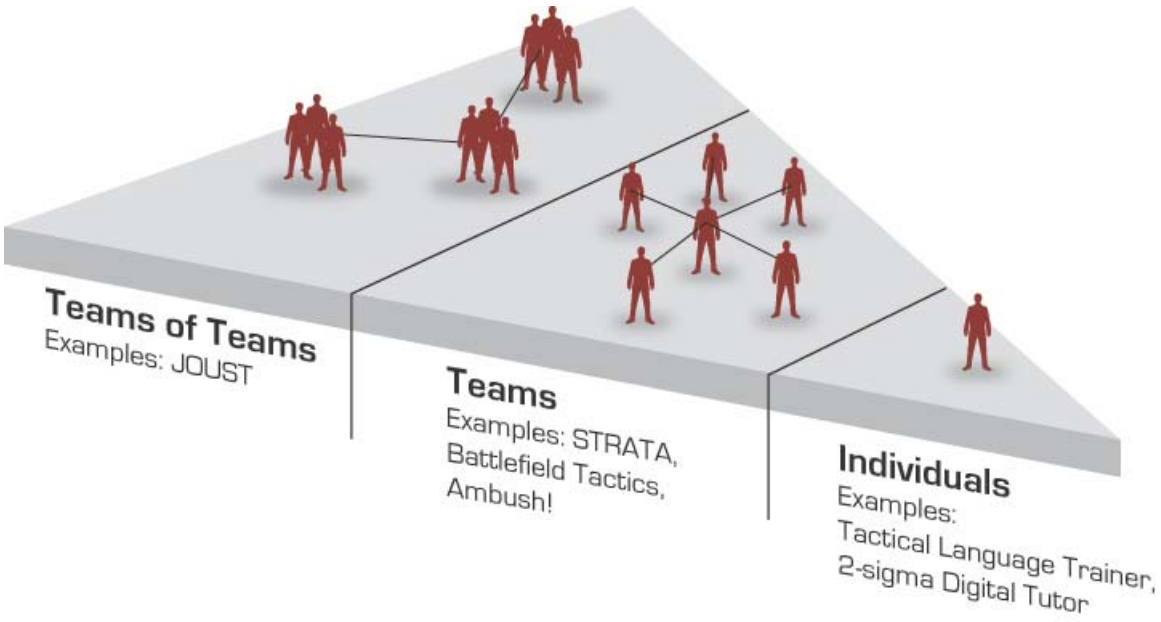

Figure 2-3: The spectrum of training in DARWARS: Ranging from focused skills training for individuals, to team coordination drills, to massive joint operations virtual exercises. The examples mentioned are part of the family of DARWARS training systems, which are described on-line at www.darwars.net

The challenge for DARWARS is to deliver tailored, relevant feedback at each level of the spectrum, from individual to team to diverse teams of teams. DARWARS is being designed to maximize the effectiveness of distributed, simulation-based training by supporting the full potential of such systems.

The coins of the realm in DARWorld are relevant, engaging experiences – to be created, discovered, and lived. Each potential experience is represented in DARWorld as a *training package* that describes the roles (human and synthetic), resources, scenarios, tutoring support, and other properties necessary to instantiate, cast, distribute, manage, and record the training session built around it. DARWorld relies on framework for describing, organizing, and matching training packages to the needs of individuals and teams. This framework is based on explicit representations of the training objectives, simulation conditions, and performance measures – enabling trainers to tailor training and AAR to individuals or smaller subsets of the larger team, while simultaneously evaluating overall mission performance, and enabling DARWorld to relate training to objectives and the knowledge and skills that underlie them, the situations or events that demonstrate them, and the metrics that assess them.

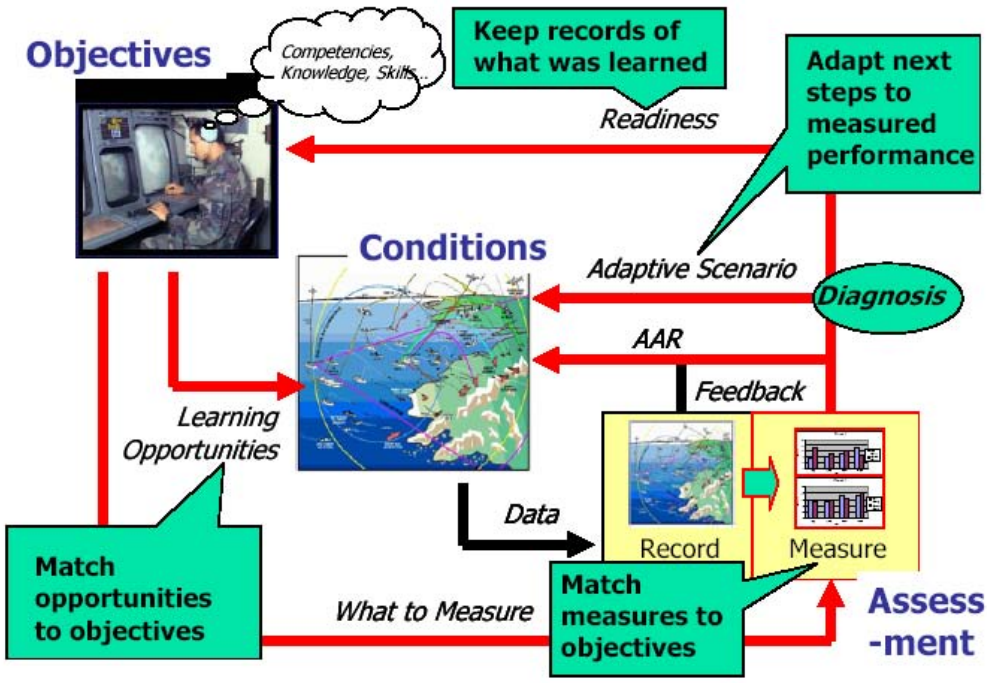

Figure 2-4: The role of Objectives, Conditions and Assessment in simulation-based training.

This explicit representation of pedagogical elements as developed for DARWARS is illustrated in Figure 2-4. Trainees have specific learning ***objectives*** to gain competencies, knowledge, or skills in specific subject or domain areas**.** They are then matched to the appropriate training experience (e.g., taking a particular role and a specific scenario) based on these ***objectives***. Trainers have the ability to craft a virtual world to help the trainee meet those ***objectives*** by specifying the characteristics or ***conditions*** of the virtual environment with more precision and control than is possible in the physical world. Trainee responses within the simulation can be recorded and contextualized in terms of the learning ***objectives***. Meaningful ***measures*** can be made based on trainee performance, recorded, and then extracted to provide assessment and feedback to trainees both during a training session (in the form of coaching) and after a session (in the form of an AAR). The measures give trainers insight into trainee progress with regards to the ***objectives***. ***Diagnosis*** of these measures enables the next match between training experience and trainee. The detailed record of performance in the simulated world may allow predictions about trainee readiness beyond it.

Explicit representation of ***measures*** with regards to ***objectives*** also allows trainers to interpret performance efficiently, diagnose the trainees' needs, and to personalize the training curriculum—all the while updating a record of the trainee's remaining objectives. Similarly, the performance of teams and other groups of people can be evaluated based on performance within the simulator and assessed in relation to past performance and established criteria. Over time, information about the progress of many

DARWARS users through multiple training experiences may reveal trends that can be used for scenario and curriculum development.

The training framework being developed for DARWARS will explicitly represent ***objectives***, ***conditions***, and ***measures.*** However, it is the explicit representation of the relationships among these elements that will allow DARWARS to provide users with the highest caliber training functionality.

Massive multiplayer experience

How would one train effectively in a universally available massive multi-player environment? Seeking answers to this question is central to achieving our vision for DARWARS, since this type of environment presents challenges for individual and team instruction. More players make situations less predictable: when there are more human players tutoring must be more opportunistic, teamwork skills become critical and can overshadow individual contributions; team building and team cohesion become a significant element of success; feedback must be crafted for several levels of participation (individuals and groups); and the events play out over longer periods of time over multiple echelons.

In 2004 we designed a project, called Gorman's Gambit, to investigate the capability of existing MMPGs to support training and to identify resources that would need to be developed to increase the training effectiveness of such applications. The project was inspired by the thesis put forth by Gen. Paul Gorman (U.S. Army, ret.) who posited that the environment of instruction (e.g., a modern military setting vs. a medieval fantasy setting) is largely immaterial if the training objective does not require a high degree of realism, such as instruction on the fundamentals of effective teamwork. Behaviors indicative of effective teamwork could be demonstrated in existing commercial games, and those games could therefore be used to teach teamwork behaviors with little alteration.

To investigate this suggestion, we conducted an exercise in December 2004. Using the existing commercial game Neverwinter Nights™, a scenario was created that was designed to support teamwork..[2] Forty members of the U.S. Army infantry at Ft. Benning, GA participated. A complete report of this exercise and implications for the use of MMPG in training is available as a separate report — "Gorman's Gambit: Assessing the Potential of Massive Multi-Player Games as Tools for Military Training." A companion report should be forthcoming from Harold O'Neil (USC), who also participated in the exercise.

We also pursued research in training through massive multi-player gaming through the development of DARWARS Ambush! and through investigations in designing DARWARS JOUST (Joint Operations Universal Simulation and Training) – a system intended to provide a distributed, persistent, scalable training environment on personal

[2] Neverwinter Nights is a trademark of Wizards of the Coast, Inc.

computers. DARWARS JOUST will provide online, real-time access to training exercises of varying scale and content, providing training in scenarios that range from individuals to teams of teams.

We have surveyed existing commercial MMPG game engines to identify the mix of features and capabilities, the technical strengths and weaknesses, and the business interests and stability of the companies involved. The process for comparison was fairly structured; with technical documentation and materials supplied by each vendor after the appropriate confidentiality and non-disclosure agreements (NDA) were executed. Additionally, several lengthy telephone interviews were conducted with the chief technical officer (CTO) of each candidate vendor in order to address specific questions, and to allow them an opportunity to speak freely about any strengths or capabilities not readily apparent from the provided literature. The following vendors were considered: Turbine Entertainment Studios, Butterfly.net, Forterra (formerly known as There), and Big World™ (a subsidiary of Micro Forte).

We chose the Big World™ engine technology offered by Micro Forte. They offer not only a demonstrated technical expertise, but also a production and design capacity that meets our needs for both the demonstration-of-concept and the development phases of the JOUST. Their connections to the Australian Ministry of Defense, and their long history of developing commercial games and commercial game engines offer a wealth of directly applicable experience. Working with them, we developed a scenario for a demonstration of the technology and produced a video including in-game play to display at I/ITSEC 2004. Our plan for 2005 is to produce an interactive demonstration and use this as a testbed for developing and demonstrating some forms of training integration.

We intend to further address the challenges in training in the large scale through several approaches:

- Develop situation awareness and event recognition capabilities to feed the opportunistic feedback and assessment required in multi-player environments. These become the triggers for actions and assessment in a fluid world of multi-person play, since scripted behaviors are not likely to prove robust in these situations.

- Develop active scenarios that go beyond scripted sequences of events to include goal-seeking contingent behavior, driven by the training objectives, as part of the scenario itself. This will require development of the automated counterpart to the game-master, or puppet-master, who orchestrates events to nudge action in the direction of instructionally relevant situations.

- Recognize the value of non-player-characters as accomplices in bringing about instructionally salient events. Informed by data in the training package, these characters can be directed to behave in ways that further the instructional goals of the scenario and its participants.

- Adapt and refocus the instructional components of relevant Training Systems to bring them to bear in multi-player settings. By encouraging the component structure of

Training Systems, and providing the means to adapt the instructional component to work with other reality engines and to cooperate in communicating with the learner, we believe the feedback and assessment expertise resident in a Training System can be applied outside the confines of its principal use – providing focused instruction in a more controlled environment.

3 DARWorld: Architecture for DARWARS

The DARWorld Architecture is a framework and environment – i.e., the common ground – for Training Systems and other training systems, as well as the social fabric to support engaged communities of learners and teachers. The architecture is driven by the pedagogical goals described in Section 2. The architecture and the roadmap for implementing it (described in Section 4) can be understood in terms of several broad categories of services:

- DARWorld Command: The user's interface to DARWorld, a Web interface that provides access to all DARWorld services.
- DARWorld Lobby: Services embedded in the DARWorld Command interface that match user and group training needs to the training opportunities in DARWorld.
- User and Group Management: Managing information about users and groups, including their competencies and training goals.
- Training Session Support: Managing information about the training applications (Training Systems), including configuring, launching, and saving results from these applications.
- Social Communications: Support for communications among DARWorld members to enable and enhance training opportunities.
- Background Services: Services such as databases and security that are required to support a large distributed system.

The architecture development can be further described in two stages. In the first stage, the services outlined above enhance training opportunities provided by a Training System by embedding the Training System in a value-added framework that makes it easy for users to select, launch and review training sessions. In this stage, the different Training Systems interface with the architecture, but not with each other. In a second stage, each Training System can provide interfaces that allow a Training System to supply and integrate training support across applications.

This section first provides an overview of the architectural components from the user's point of view and then discusses the architecture in terms of the DARWorld Command user interface, the Lobby, User and Group Management, Training Session Support, Social Communications, and Background Services. Finally, the second phase of architecture development, Training System Interoperability, is discussed in Section 3.8.

3.1 Architecture Overview

The Training Systems are the central components of the DARWorld architecture. Training Systems provide training experiences for users; they are the source for instruction about particular skills and knowledge, and the interface to simulated worlds.

The DARWorld architecture enables and enhances the training opportunities provided by the Training System by supporting users in locating appropriate training opportunities, launching training applications, and sharing and reviewing training results.

Users interface to DARWorld through a Web portal, referred to as DARWorld Command. Through DARWorld Command, users and groups manage information about themselves, including their training objectives and competencies. They can also search for and obtain information about training opportunities provided by Training Systems; coordinate, launch and review training sessions; and interact with other users through various communication tools. This is illustrated in Figure 3-1.

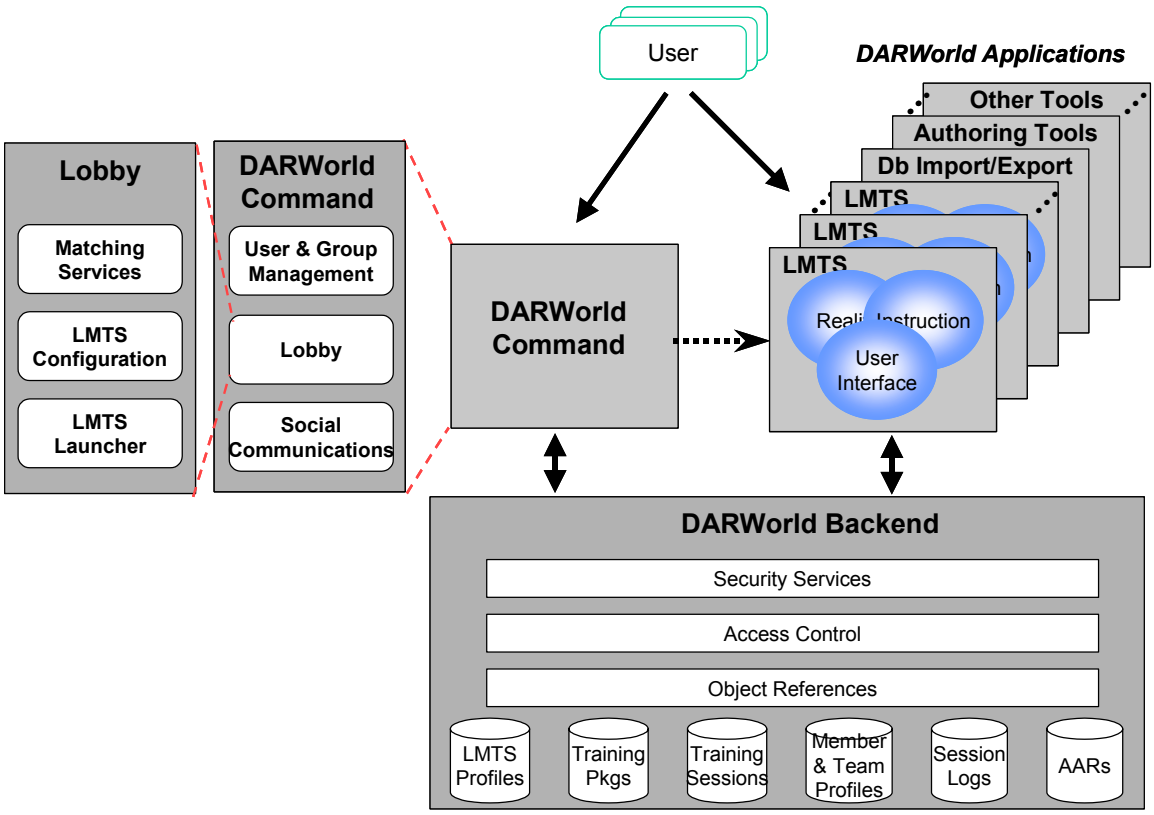

Figure 3-1. DARWorld Architectural Overview: Functional Details

The DARWorld background services, though not visible to the user, provide the necessary infrastructure, storage, communications, and security to support the DARWorld system.

3.2 DARWorld Command

This is the user interface to DARWorld. DARWorld Command is a Web-based interface that provides access to all the DARWorld services. In some instances, DARWorld services appear as explicit links on a Web page, for example, to access instant messaging and email clients. In other cases, DARWorld services are seamlessly integrated as, for example, when a list of training opportunities is presented to the user after DARWorld has determined appropriate matches from User and Training System Profiles.

3.3 Lobby

The primary purpose of the lobby is to support selecting, configuring and launching training opportunities. The lobby is incorporated into the DARWorld Command interface; when configuration is complete, a simple button click invokes the lobby's launching capabilities and the selected training session is launched.

The lobby incorporates several services:

- Matching appropriate training opportunities to users and groups, ensuring that the users and groups have the competencies required and that the training opportunities meet the users' training goals.
- Configuring training sessions using the tools described under Training Session Support so that all required parameters for the training session are set.
- Ensuring that appropriate versions of the training application and all support applications are available.
- Launching an application for a single user and coordinating launch of multiple instances of an application for a group.

3.4 User and Group Management

The primary purposes of the user and group management tools are to identify users and groups and their training needs. The user and group management tools provide the information on members' competencies and training objectives that is used by the lobby to determine appropriate training opportunities. Competencies and training objectives may be automatically updated when the user participates in training sessions or may be explicitly updated by commanders, coaches, instructors, and other assessors as appropriate.

User and Group Management includes tools and interfaces for creating and editing such characteristics as:

- users' identities (e.g., name, address, email address, etc.) and roles
- users' group membership
- access control to user and group information
- users' and groups' competencies and training objectives
- preferences for tailoring the DARWorld environment and for tailoring individual applications

In addition, these management tools help support the multiple roles that a user or group can assume. The term "role" in DARWorld refers to one of three capabilities:

- The role that a user has within a training application (Training System), for example, a platoon leader or infantryman. The role is selected based on the user's training goals and the training opportunities provided for each role within an application.
- The role that a user has within DARWorld, for example, instructor or trainee. The user may assume multiple roles, for example, the captain may be an instructor for his platoon, while being a trainee in a leadership course. Again, appropriate roles are selected for each training session based on the users' training goals and the training opportunities provided.
- The role that a user or group has for purposes of controlling access to user or group information. For example, a user may allow access to their training results to members of a specific group or to all instructors.

3.5 Training Session Support

The primary purpose of training session support is to provide the information needed to match a training opportunity to a user's needs, to launch a training application, and to record training activity results. Training session support is provided through a series of interfaces that transform a training application into a specific training event.

- First a training application is described in terms of the resources it requires and the parameters that configure the application. This description is called a Training System Profile.
- Next, training applications are configured (and can be combined) by selecting specific resources and parameters. A training application may be configured to provide specific training objectives or to require specific competencies. In addition, a training application may be configured differently for different roles within the application, or within DARWorld. This configuration is called a Training Package.
- The information required to launch a Training Package for a particular user or users is specified as a Training Event. i.e., a Training Event is a training package plus a set of bindings for the parameters of the package.

The execution of a training event is a training session. All activities and results of a training session are recorded in a Session Log.

3.6 Social Communications

Social communications tools are collaborative tools that support communications to enable and enhance training opportunities. These tools are integrated within the DARWorld Command, providing easy access before, during, and after training sessions. Communications tools include the following:

- Instant Messaging: Instant messaging provides an interactive environment for users to converse by typing short messages and responses. Users are able to hold

conversations with other participants for such purposes as organizing team training events, communicating to other members during training events to obtain and provide advice, and sharing training experiences.

- Email: Email is used to exchange messages to organize training events and share experiences. As DARWorld training sessions are URL addressable, users are able to launch and share these sessions by including references in emails.
- Wiki: A wiki is a collection of Web pages that can be edited by anyone, at any time, from anywhere. Wikis provide a mechanism for displaying and modifying shared training information in an organized manner.

Implementations of these tools will be selected and integrated into the DARWorld architecture. Thus, for example, a user exploring the relevance of a particular training opportunity may be presented with wikis discussing hints and results from other users' interactions and email discussion lists about that training system. When a training session is launched, an IM session may be simultaneously launched to support interaction with other users, coaches and instructors.

3.7 Background Services

A number of background tools and services are needed to support the DARWorld distributed system. These include:

- A database for storing information about users, groups, and training applications. This includes user and group identification, training objectives and competencies, Training System Profiles, Training Packages and Training Events, and results of training sessions, including after-action-reviews.
- An object reference service that supports referencing components by URL. For example, a Training Event package may be referenced by URL, thus allowing the user to launch a training application by simply specifying the URL. Similarly, an after action review may be referenced by URL, allowing users to easily share these results by emailing the URL.
- An access control service that allows users and groups to control access to information about themselves. For example, a user may allow access to contact information, such as an email address, while restricting access to their competencies and objectives.
- Security controls that provide secure access to information in the database, as well as secure communications among DARWorld services and tools using public key encryption.

3.8 Training System Interoperability

The DARWorld architecture is designed to facilitate training by providing mechanisms for the integration of training applications into a larger system with support for user management, training session management, communications and backend services as described above. In addition, Training System development can be aided, and training opportunities can be enhanced, by integrating components developed for one Training System into other Training Systems. We are investigating several approaches to Training System interoperability, including:

- Instructional components originally designed by one Training System may be incorporated in another Training System. For example, a coaching component designed for one application may be adapted to support another application. Alternatively, instructional components may be designed independent of a specific Training System, and incorporated in the Training System.
- Training Systems may support simulation interoperability. Training Systems that employ the same reality substrate may be adapted to support a common scenario in which each Training System offers different, but simultaneous training opportunities.
- Training Systems could be combined in a package to provide training across a variety of scenarios. A trainer could build a coherent training opportunity by assembling a storyline from scenarios taken from a range of training simulation systems. This is particularly useful when the trainer wants to represent a large mission, where "large" could refer to one that spans days, or that involves joint forces operating across multiple battles and terrain, or that involves distributed teams that commonly work together (e.g., artillery and light infantry, close air support).
- Key components identified by Training System developers may be shared through interfaces developed for these components. For example, speech recognition or expert reachback management may be common requirements of several Training Systems that are eventually provided by one Training System developer with appropriate interfaces that promote reuse.
- DARWARS could enable the integration of lecture like materials, electronic textbooks, and SCORM-compliant materials, tests, and exercises with more immersive training media (we call this cross-system training). For example, trainers may seek the ability to stop a scenario for a more lecture-like treatment of a topic, particularly if introducing a new concept to trainees. Similarly, drill exercises in standard testing formats such as multiple-choice, etc. have their uses in helping trainees practice declarative knowledge (e.g., brevity codes) until it is more automatically recalled.

The DARWorld architecture will initially provide services and tools to enhance training opportunities provided by each Training System. In the initial phases of the architecture development, the Training System was embedded in the DARWorld architecture with minimal impact on the individual training application implementations. Over time, the training applications themselves may be reorganized to encompass common components, thus improving training by integrating with the best services available.

4 Roadmap for Implementation and Integration

The roadmap in this section describes the details of the integration plan. Integration involves two major tasks: implementing the infrastructure and integrating training systems.

- Implementing the infrastructure. The infrastructure will include services for matching training opportunities to training objectives at both the individual and team level. It will also encompass services for configuring and launching training applications, and reviewing and sharing results of training sessions. This infrastructure provides much of the value added of DARWorld by supporting the goals of universal training access, increased training effectiveness, and reduced training development costs. A plan for incrementally building the infrastructure is detailed in Section 4.2.

- Integrating training systems. The Training Systems are the key instructional components of DARWorld. In order for DARWorld to be a compelling and easy-to-use environment, the Training System must be seamlessly integrated into the infrastructure. For DARWorld to provide value for Training System developers, the infrastructure must provide services they need, and must be easy to integrate with their applications. As developers of the infrastructure, one of our tasks is to support DARWARS developers in this integration. The integration task is described in more detail in Section 4.3.

In Section 4.1, we first describe the milestones on the path to DARWARS; these milestones help us coordinate and schedule more detailed tasks. Sections 4.2 and 4.3 provide more detailed plans for implementing the infrastructure and integrating training systems, respectively.

4.1 Milestones

The milestones are scheduled from the beginning of the contract. That is, the first milestone (The Way to DARWARS) is labeled as 6 months (October 2003). Subsequent milestones occur during the contract Option phases. BBN proposed two Option phases: an additional 12 months to correspond roughly with the end of the first phase for Training System contractors and to also correspond with DARPA requirements for releasing FY 2005 money; followed by an 18 month option to complete the 3-year contract proposal. The DARWARS for Others (18 months) milestone corresponds to the end of the first contract Option phase (which is now); DARWARS for Everyone (36 months) corresponds to the end of the second contract Option phase.

The Way to DARWARS (6 months = end of base phase, October 2003)

We defined a DARWARS architecture and delivered Integration Plan v1.0 for implementing the DARWorld infrastructure to instantiate the architecture. The architecture summarized in Integration Plan v1.0 was described in detail in our deliverable document DARWARS Architecture. A first version of the interface specifications and capabilities that we needed to build to support the integration of Training Systems into the architecture was provided in our deliverable document DARWARS Developer's Guide. In addition to these documents, we prepared and presented an operational concept demonstration of DARWorld as we envisioned it at the completion of this effort.

DARWARS for Us (12 months)

We developed an initial infrastructure prototype, called DARWorld, which tests the feasibility of the architecture and provides a working instance of the DARWARS training environment. Our working instance of the DARWARS training environment now includes basic functionality for member access and management, training system management, training package management, training session management, a training system launcher, social infrastructure and user interface.

We started expanding into the DARWARS For Others phase; working with other DARWARS PIs to demonstrate launch of their systems, and to establish requirements for more depth of integration of their systems within the DARWorld Training Environment. We demonstrated some results of these activities with a booth and a live demo of the Training Environment at the Joint Warfare Conference in Washington, D.C. in June 2004.

We also pursued research addressing the issues of creating effective team training within DARWARS. We developed an organizing framework – a "pedagogical ontology"- that can be used to specify both what is to be learned in DARWARS training sessions and the progress made by learners towards meeting their training objectives. We have implemented a rudimentary model of learners and objectives, and searches for training based on those objectives.

DARWARS for Others (18 months, January 2005)

This point corresponds to a milestone for many of the Training System contractors, and is also the end of BBN's Option 1 contract phase (January 2005). At this point we have demonstrated a DARWorld prototype with more robust versions of the DARWorld for Us services and active use of training objectives in defining profiles and identifying training opportunities. We also provided updated versions of our Architecture Document and Developer's Guide.

A major accomplishment was our participation at the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC 2004) held in Orlando in December 2004. Development focused on completing and testing the integration of the various Training Systems that were demonstrated in the booth, and worked to insure the stability and reliability of the infrastructure supporting those demonstrations. The architecture now supports the functionality of packages and objectives, matching trainees with training, IM, lobbying, launching and content distribution. In the demonstrations at I/ITSEC nine program and non-program systems were searched for by objectives, found, lobbied and launched from DARWorld (i.e., they had defined packages with objectives that matched student requirements, and were running in a distributed fashion from our DARWARS server).

We completed specification of an organizing framework that can be used to specify both what is to be learned (learning objectives) in DARWARS training sessions and the progress that is made by learners towards meeting those objectives. This specification is

documented in a white paper, "DARWARS: An Architecture That Supports Learning," and will be used going forward.

At this point in time, DARPA has a Memorandum of Agreement (MOA) with the Program Manager for Training Systems (PM TRASYS) Marine Corps Systems Command, and is working on an additional MOA with U.S. Joint Forces Command. We will be working closely with these MOA partners to develop infrastructure capabilities that support transition to their programs.

We will continue to support the integration of our program co-contractors' Training Systems into DARWARS. The most immediate point of integration will be the creation of a Training Profile for each learner using the Training System. Future infrastructure capabilities will be based on Use Cases developed in conjunction with our program and MOA partners. Such capabilities could include, for example, scenario design tools, AAR tools, or community building tools for learners and for instructors.

Our research will continue to concentrate on the requirements for instructional services for team training, in particular AARs, and on refining our ideas on group objectives; and will also look towards requirements for integrating objectives of different training applications.

DARWARS for Everyone (24 months)

At this milestone, we expect the infrastructure will provide more support for learner profiles, and will have made strides towards group training objectives and competencies – maintaining and providing access to group information and using group objectives and competencies in selecting training sessions. We will have defined a series of integration "levels" and expect to have "upgraded" the integrations with the previous Training Systems by incorporating learner profiles and further instructional services (e.g., AAR) into those integrations. We will be in the process of developing initial prototypes for our MOA partners, and will upgrade the infrastructure in response to comments from trainees, instructors, developers and other DARWorld members. Infrastructure development for the remainder of the program is expected to concentrate on upgrades and enhancements identified by these users and, in particular, our MOA partners.

We will continue to develop and refine our ideas on group training, and will have begun work to incorporate these training capabilities into a Training System that specifically supports group training. Our research will continue to emphasize team training objectives and team competencies, and we will also be looking more closely at Training System interoperability. We expect to be sharing AARs, and to have begun tests with sharing other instructional components among Training Systems.

We hope to have identified a partner for incorporating an instructional MMOG into DARWorld. This is an important, and currently unfunded, aspect for achieving the full vision of DARWARS. Our research will continue to include consideration of massively multiplayer environments; funds to develop such a training application would allow us to best illustrate the goals of DARWARS and the results of that research.

We will demonstrate a prototype for PM TRASYS in September 2005, support an exercise in January 2006, and expect to have further demonstrations of DARWorld at I/ITSEC ’05.

DARWARS Forever (36 months)

At the conclusion of the contract, we will have a full working prototype of DARWorld, with a wide variety of available training applications, tools and services, in use by instructors, trainees, developers, subject matter experts, administrators – an entire training community. We will have demonstrated the interoperation of Training Systems, published papers on our activities and results in exploring team training objectives and team competencies, demonstrated DARWorld regularly, and will have identified a business plan and process for transition to a DARWorld caretaker who will continue to upgrade and enhance DARWorld, and who will facilitate its use in a wide variety of training environments.

4.2 Implementing the Infrastructure

This section describes an incremental approach to implementing the DARWorld infrastructure following the architecture design. At each milestone, the implementation plan is designed to establish a new level of functionality for developers to use and for DARWorld to demonstrate. Each milestone is, in effect, a new release of the infrastructure that has been tested, can be demonstrated, and is available for integrating Training System development within DARWorld

4.2.1 Infrastructure: 12 Months

The first milestone, at 12 months from the start of the contract, provided a prototype implementation of the architecture that was delivered to Training System developers as a basis upon which they could start integrating their systems. In this prototype most, but not all, of the DARWorld services were represented. In most cases these were not full implementations of the services, but were sufficient to show the lifecycle of several of the facets of DARWorld. This implementation was aimed at individual users (trainees, trainers and developers), and allowed a trainee to choose and launch a training experience.

This first implementation demonstrated initial versions of the following:

- DARWorld Command – The Web interface encompassed instructor and trainee web pages with links to a lobby for launching training events, user management tools, training session support tools, and social communications tools.

- Lobby – This version supported selecting participants for specific training roles, participants rendezvousing in preparation for training, and launching an appropriately configured Training System for each participant. This capability built upon the Training Event Editor (see below) by using its ability to add bindings to the Training

Event that are required by the Training System; in addition, some bindings are automatically determined by the Lobby (e.g., the user's IP address).

- User Management – This version supported:
  - Creating and editing member profiles for individual users, including basic information (name, email address) and roles within DARWorld (e.g., trainee, coach, instructor, commander, etc.)
  - Controlling access to member profiles via passwords.
  - Database access (storing and retrieving) of these basic member profiles.
- Training Session Support – This implementation provided basic tools for specifying training sessions: defining requirements of a Training System, defining applications (packages) to use a Training System, and specifying package bindings for specific events.
- Training System Profile Creation and Editing –This initial implementation included support for:
    - Specifying the configuration of the Training System, including command line flags and parameter names and allowed values.
    - Specifying files, such as configuration or scenario files, which must be bound and possibly downloaded before launching the application.
    - Providing a human readable description of the Training System to aid users in selecting and configuring appropriate applications to meet their training objectives.
    - Storing and retrieving Training System Profiles from the database.
  - Training Package Creation and Editing – A tool for specifying a particular configuration of a Training System; configurations may vary depending on the role of the user within the Training System (e.g., platoon leader, infantryman) and the role of the user in training (e.g., instructor, trainee). Support for:
    - Retrieving Training System Profiles from the database.
    - Creating a new Training Package by querying the user to supply the configuration information described in the Training System Profile.
    - Storing and retrieving Training Packages from the database.
  - Training Event Editor – The training event editor provided support for:
    - Selecting participants for roles in the Training Event.

        - Scheduling the Training Event for a specified date and time.
        - Saving Training Events in the database.
    - Session Log – The initial session log support included tools for recording and retrieving information from a Training Event. This included:
        - Interfaces for applications, such as a Training System, to create and append to a session log.
        - Session log server to accept data from applications and record it in a session log.
        - Ability to save and retrieve session logs from the database.
- Social Communications – This first implementation included tools for supporting communications among DARWorld members for enabling and enhancing training.
    - Third party tools were selected to support Instant Messaging (IM).
    - The Instant Messaging client was integrated into the DARWorld Command Web portal.
- DARWorld Background Services – Activities involving the basic tools for supporting the DARWorld distributed system included:
    - Selection of a database for supporting DARWorld.
    - Selection and configuration of web services tools to support communications between the DARWorld Server and applications and web based servlets.
    - Support for storing and retrieving Member Profiles, Training System Profiles, Training Packages, and Training Events.

4.2.2 Infrastructure: 18 Months

The second implementation milestone fell at 18 months from the start of the contract. The initial implementations provided in the first period were further developed, and refinements suggested by Training System developers were incorporated. The following list describes the additional capabilities that were provided in this time period to enhance the basic areas in DARWorld for Us. These capabilities included use of training objectives in Training System profiles, Training Packages, events, and User Profiles; improved support for communications and home pages; improved security; and the inclusion of DARWorld Object References for identifying and retrieving DARWorld entities such as profiles, packages and session logs.

- DARWorld Command

  - Continued improvements to the web based interface to DARWorld to support new functionality and improved usability.

- Lobby
  - Support for multiple members to assemble for participation in a training event.
  - Integration with instant messaging so that potential participants can be sought and can join the event.
  - Support for an individual to register interest in ad hoc training, and support for locating and notifying individuals who have registered an interest.

- User and Group Management
  - Member Identification – Support for:
    - Specifying access for different categories of data (e.g., contact information, competencies, training results) for specific individuals, groups, and roles.
    - Providing access control for reading and updating Member Identification and Training Profiles.
    - Specifying personal profiles and DARWorld portfolios (training results).
  - Member Training Profile – Support for recording training objectives and achievements including:
    - Support for instructors or other qualified members to assign training objectives to members.
    - Support for members to assign training objectives to themselves.
    - Support for updating training achievements either by the Training System or by human assessors.
    - Support for storing and retrieving Training Profiles in the database.
  - Group Identification – Support for groups included:
    - Group creation and editing, i.e., specifying membership in groups.
    - Storage and retrieval of group information from the database.
    - Addition of group information to member profiles, i.e., indicating group membership in individuals' profiles.

- Training Session Support

- Training System Profile Creation and Editing – New capabilities included:
  - Support for roles required or provided by the Training System.
  - Support for configuring multiple instances of a Training System including both a shared configuration and a role-specific configuration. Role-specific configurations specify parameters that must be supplied and are dependent on the role of the user in the application or in DARWorld.
  - Support and configuration for resources, i.e., external servers, required by a Training System.
- Training Package Editor – Additional capabilities included:
  - Enhanced configuration of several Training System instances including specification of both shared and role-specific configuration parameters.
  - Definition of an ontology for specifying training objectives.
  - Specification of training objectives provided by a training package.
  - Support for specifying "pre-brief" information that participants may display prior to a Training Event.
- Training Event Editor
  - Improvements for usability.
- Session Results
  - Store and retrieve documents resulting from a training session in the database. Documents may include text, images, audio, video and references to Training System events as supported by the Training System.
  - Link the Session Results to the Session Log and Training Event.
  - Support for saving documents in a Training Session and retrieving them in a corresponding After Action Review Session.

- Social Communications - Instant Messaging (IM) was integrated with the member database, including support for:
  - Temporary buddy lists of training session participants.

- DARWorld Background Services
  - Resource Manager - The resource manager resolves references to external resources in Training System profiles and supplies the resultant bindings to the launcher for use in launching each resource. The Resource Manager determines

and enforces the launching of shared and individual resources. The Resource Manager supports several variants on sharing, including sharing a resource across a Training Session, and sharing a resource across all identical Training Systems in a Training Session.

4.2.3 Infrastructure: 24 Months

The third milestone falls at 24 months from the start of the project and will be focused on pedagogical concerns of training systems. Infrastructure support for group training will be developed in this period.

- Expanded Pedagogical Support
    - Support specification of hierarchical objectives, conditions on objectives, and measures of proficiency and exposure against those objectives in order to more precisely define the training offered and the trainees' achievements. Provide methods for combining trainees' scores on sub-objectives in order to produce scores for objectives.
- Lobby
    - Group training objectives and competencies will be adhered to when selecting groups to participate in training sessions.
- User and Group Management
    - Group Profiles
        - Group training objectives will be supported, but only rudimentary distribution of group objectives over individual objectives and aggregation of individual objectives into group objectives will be developed.
        - Group training achievements will be recorded and available for selecting groups to participate in training events.
- Training Session Support
    - Training Package Editor - Training packages will specify what group-training objectives are required and addressed.
    - Linkage of training roles to objective conditions will be implemented. This linkage augments the linkage of the training role to objectives by defining the conditions that the training role addresses as well.
    - Session Results – This implementation will support storing arbitrary documents resulting from a training session or its AAR.

- Social Communications – Additional communications to support groups will include functionality such as IM lists, email lists, and wikis tailored for the group.

- DARWorld Background Services

  - Security

    - Communication Security will be provided among all servers and clients using certificates and encryption.

    - Access Control will be provided for all DARWorld objects.

  - DARWorld Object Reference – Access to additional DARWorld data components will be supported with URLs as required.

  - Data Management

    - This implementation will support garbage collection - finding and deleting data that can no longer be accessed via DARWorld object references.

    - Provide support for tracking storage ownership to individuals and groups to monitor use and promote timely cleanup.

4.2.4 Infrastructure: 36 Months

The final milestone falls at the end of the project (Summer 2006). The exact implementation activities will depend in large part on results of discussions with DARPA's (and thus our) MOA partners. However we expect to continue to make DARWorld more robust, to support our team and colleagues in using the infrastructure as a foundation for experimentation in our research, and to support development and testing by the Training System co-contractors. We expect our work to focus on Training System interoperability and team training. We will also work on refining tools that are in use by Training System developers, and on working with those developers to identify and build additional tools that will aid in interoperability.

4.3 Integrating Training Systems

Whereas Section 4.2 presents a plan for developing the infrastructure capabilities needed to support training applications, this section gives a plan for actually integrating these applications into DARWorld. It is useful to note that development of the interfaces and tools needed for integration is included in the infrastructure development plan; research needed to support integration is discussed in the R&D plan; outside requirements that may influence the order and level to which specific Training Systems are integrated are discussed as part of the Transition plan. This section describes how we currently anticipate all of these fitting together into a plan for incorporating Training System development into the infrastructure and demonstrating that integration.

In general this task began with interactions with co-contractors to further define and design interfaces and to assist them (and our subcontractors) in preparing demonstrations of integration with DARWorld. As we enter the second half of the project, our MOA partners' requirements will give additional direction to integration activities. We anticipate that each MOA partner will have specific training systems and DARWorld services that interest them. We will develop a plan that reflects the desires of both partners and serves their combined interests.

To date developers can install their own DARWARS server or can work with BBN's online server to test their Training System implementations within DARWorld – they can access the infrastructure and tools, access and load code, build packages and enter trainee information, and test their implementations. Our approach to the DARWARS architecture supports a continuous integration process in which developer teams conduct coordinated integration based on milestones. In our next phase our Web-based demonstration environment will provide access to DARWorld for trainees, instructors and other members as appropriate. Finally, integration includes regular releases of documentation (e.g., Architecture Design and Developer's Guide) of particular relevance to Training System developers.

The integration described herein will be based on milestones and is coordinated to use and illustrate specific architectural capabilities. As we proceed, we plan to include within DARWorld our reference implementation, MÄK's HLA-based implementation, the various training systems under development by the DARWARS program, Training Systems, tools and concepts developed by the SBIR co-contractors, and if possible a training system (Full Spectrum Command/Full Spectrum Leader) under development by our subcontractor Quicksilver (and in early use in the military). Other candidates for integration will emerge from discussions with our MOA partners. For example, PMTRASYS has expressed interest in two game-based training systems being developed by Destineer (Close Combat: First to Fight; Red Phoenix), which will be considered for integration.

We will define an "integration ladder" that delineates a progression of integration levels for training systems to achieve. Integration is progressive in the sense that applications may be integrated into DARWorld initially at a level of simply being launched within the lobby, but will be upgraded as more functionality (on the part of the Training System and/or DARWorld) is developed. Higher levels of integration will require more effort on the part of training system developers, but will provide higher value to the users. Our goal is to promote higher levels of Training System integration across the board, facilitate complete integration with the OCM (Objective-Condition-Measure) Framework being developed, and demonstrate instructional interoperability (as well as simulation interoperability) across Training Systems in DARWARS.

4.3.1 Integration: October 2003

We worked closely with the funded Training System providers to develop an architecture that incorporated their ideas and plans for training system development, and we described the services, tools and other components needed to realize that architecture. Our

integration plan described the results of these integration activities and our Architecture Document and Developer's Guide provided initial guidance.

4.3.2 Integration: 12 Months

- DARWorld Test Bed – We established a network-available test bed for use by DARWARS program developers. This test bed houses the current version of DARWorld and is refreshed nightly with the latest software version. In addition, we established and manage a software development repository for sharing software releases within the DARWARS program. The repository holds the latest version of the software including the Training System reference implementation and other simple training system examples. The repository and test bed are available 24 hours[3] every day to allow the DARWARS participants to access the infrastructure and tools, access and load code, and test their implementations; it provides shared access as desired to participant products.

- Reference Training System Implementation – This initial version of the reference implementation displays its parameters to confirm that all configuration steps leading to its launch have operated correctly; it makes session log entries to document its launch and has controls to permit the user to make additional session log entries.

  In addition to the reference training system, a simple two-person training system "trains" the players to play tic-tac-toe. This training system illustrates the integration of multi-player training systems into DARWorld.

- Training System Integration – The reference implementation has been integrated within DARWorld as an example for integrating the results of Training System providers over the next six months.

- Demonstration – In this phase of the project we gave a live demonstration of its capabilities at the Joint Warfare Conference in Washington, D.C. in June 2004. The demonstration included the BBN-developed core integrated with training systems developed by MÄK and Sonalysts[4]. The MÄK training systems were adapted to enhance their integration into DARWorld. At this milestone, we demonstrated the basic DARWorld capabilities developed during these six months.

4.3.3 Integration: 18 Months (Now)

- Training Record – We designed and implemented a training record capability for recording the outcomes of a user's training sessions. Training systems can add

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[3] The DARWorld server is shut down briefly early every morning to install the latest software version.

[4] Called the Battlefield Tactics Trainer (BTT), this is a federation of three training systems: MAGTF-XXI, BC2010, and Fleet Command.

training records using the DARWorld web service API. The training record is part of a trainee's training profile and serves to track the student's training progress in DARWorld.

- Enhanced Launch Capability – Based on observations of potential training systems' needs, we enhanced the DARWorld launch capability to include servers and helper applications such as VoIP clients used during training session. The launch capability is very flexible and can accommodate a wide range of training system configurations.

- AAR Support – DARWorld supports after action reviews (AARs) by treating the software applications of the review as training systems. It is possible to upload the products of a training session (for example, a log file recording all the events of the session) and download those products to be played back by the after action review software. This capability was tested with the MÄK Battlefield Tactics Trainer, which has the capability to play back a recorded event log.

- Training System Integration – As part of our preparation for I/ITSEC 2004, several training systems were integrated into DARWorld and subsequently launched by DARWorld during the conference. In some cases, integration was superficial, but the ease of integration was highlighted. The integrated training systems included some not developed under DARWARS funding.

- Demonstration – In addition to the demonstrations at I/ITSEC '04, we also demonstrated a developer loading a new training system[5] into DARWorld, defining an objective and training package for it, defining a training event for three players, and finally launching a training session. The training system requires a server to support the session and that was included in the demonstration as well.

4.3.4 Integration: 24 Months (Summer 2005)

- DARWorld Test Bed – The current test bed will continue to be available, but we may stand up another server instance to be operated less dynamically. If more training system developers come to rely on the availability of a test bed, software updates will need to be more tightly controlled.

- Training System Reference Implementation will be enhanced as necessary to test and demonstrate the infrastructure features developed during the period leading to this milestone. This includes support for team training interfaces, group identification, increased security features and social communications for groups.

- Training System Integration – We will define standards for a few levels of integration. These standard levels represent milestones in the integration of a training

[5] The training system was *Neverwinter Nights,* a role-playing multi-player game.

system. Training systems will be able to characterize themselves in terms of these standards.

  - All DARWARS training systems should be integrated at the basic level within DARWorld, and the applications previously integrated will be upgraded to use DARWorld team training support as appropriate.

  - The MÄK *Battlefield Tactics Trainer* will be integrated at an instructional level.

  - Quicksilver's *Full Spectrum Command*/*Full Spectrum Leader* will be integrated at the basic level, and at an instructional level as appropriate.

- Team Training – The use of groups (teams) within the DARWARS core will be more prevalent. Teams will be equivalent to individuals in many cases. For example, a participant in a training session could be a team. We have observed that some training systems (notably MAGTF) often use a small team (e.g. three individuals) to man each training station. In such a situation it is not possible to observe individual performance, but it is possible to observe and record team performance and perhaps deduce individual performance. DARWorld needs to be able to handle this.

- Demonstration - We will demonstrate a trainee and a trainer using DARWorld and choosing from a small selection of training applications. We will also demonstrate the instructional capabilities of DARWorld by following an individual training session through its AAR.

4.3.5 Integration: 36 Months (Summer 2006)

All DARWARS Training System providers will be integrated as DARWorld applications, at the level of team instruction if appropriate. At least two of these providers will interoperate. We expect, in particular, that MÄK's HLA-based implementation will be integrated within DARWorld with another Training System based on a different reality substrate. Additional training applications may also be integrated if available. These may include any of the following, dependent on the availability of funding, and the priorities of our transition partners:

  - Quicksilver's Full Spectrum Command/Full Spectrum Leader.

  - Additional HLA-based Training Systems, incorporated into the system developed by MÄK.

  - Training based on massive multiplayer online games.

At this stage, the test bed will be a prototype of DARWorld that incorporates all tools that have been developed by BBN and Training System providers, libraries and other tools for future Training System development, and the various Training System applications developed both within the program and with additional funding, at appropriate levels of integration. DARWARS will provide this prototype of a seamless environment for use by trainers, trainees, subject matter experts, developers, and administrators to develop,

deliver and engage in innovative Training System training. This prototype learning environment, including documentation and example demonstrations, will be delivered to DARPA and to our transition partner.

5 Transition

How can we act to ensure a long life for DARWARS? Who will shepherd DARWARS beyond the current program? We acknowledged from the outset the importance of addressing the program transition– finding transition partners who can validate and, if needed, influence the overall direction, who will work with us to attract developers, experts, and trainees, who will continue to support the development of individual Training Systems, and – most importantly – who recognize the critical advantages of the DARWorld infrastructure in delivering and supporting training technologies. In thinking about how to transition the program, we have recognized the potential value of DARWARS beyond the training community. The shared capabilities provided within DARWorld – the ease of crafting scenarios, gathering players, staging exercises, collecting and analyzing data, and reviewing the results – are capabilities that are useful in a variety of situations that are not traditionally considered training; *e.g.*, exploring the implications of new weapons or other technologies, new tactics and counter-tactics.

How do you train for situations for which no doctrine has been written? You acquire these skills by practice encounters with new and unexpected situations. The ease with which these experiences can be crafted, and teams formed to execute and review the experience, is valuable to the experimenter and to the trainee.

In addition, we observe that training for future conflicts will have experimental overtones. Working within a DARWorld scenario could provide experience in confronting novel events, promote team building skills and learning to work within ad hoc teams, and in using computer and social networks effectively. Similarly, DARWorld supports rapid construction and delivery of scenarios that could be useful for mission rehearsal.

5.1 The pragmatics of DARWARS growth

We firmly believe that growth by accretion will not achieve the DARWARS vision unless it occurs within an established well-crafted pedagogical framework. Although the World Wide Web was built through accretion, its emergence depended on the prior existence of the Internet; a system that was deliberately designed and engineered. Consequently, the DARWorld infrastructure is designed as an open environment that makes full use of available standards, best practices, and contemporary trends in enterprise computing. We also view our role as a clearinghouse for tools and components developed by Training System providers and by ourselves.

We believe the DARWARS program will create a “pull” through its architecture and learning technologies that attracts: trainees with the promise of superior training and compelling experience; trainers by offering access to a large motivated audience;

technology developers with tools, a framework and an audience; and the military services with superior, continuously available training that ameliorates the problem of skill decay.

5.2 Transition Planning

The training revolution that DARWARS begins can be fully brought to bear on the training requirements of today's military force through transition of the DARWARS program to the Services. We believe DARWARS transition should address three main goals:

1) FY '06 Funding Support based on early securing of DARWARS partners including DARWorld customers, Training System clients, and MMOG partners.

2) Program Transition to a responsible organization with a business plan and model for continuing support.

3) Training Revolution through influence of DOD and related departments and/or agencies to create a solid and contributing customer base, and influencing policies needed to effect the revolution in training that DARWorld can implement.

We have been working towards these goals, have achieved the first and as a result are well positioned to accomplish the rest. At this point in time, DARPA has a signed Memorandum of Agreement with one partner and is negotiating another MOA, insuring FY06 funding support for DARWARS Architecture Integration and transition to those partners. We will work in the near term with these MOA partners to determine business plans and models going forward with their organizations. In addition, we will continue to work with these partners, and others as needed, to insure that the vision of DARWARS outlasts the program itself. A detailed plan for achieving this is not included here, however v1.0 of this document included, as its Appendix A, a document giving recommendations on how to move forward with transition. Although we do not completely agree with all of the recommendations in that document, we do believe it still forms a good foundation for BBN, in cooperation with DARPA's DARWARS program participants, and DARWARS partners to continue to develop more concrete plans for transition activities including developing a model(s) for sustaining DARWARS through transition.

6 Summary

This document has presented both an overview of our DARWARS vision, an update of the status of the project through BBN's Option 1 phase, and specific details on how we will continue to achieve that vision through further implementation of the DARWorld infrastructure and integration of training systems. In addition, it notes that DARPA has signed one MOA and is in the process of negotiating another one to transition the DARWARS program to the Services, where the training revolution that DARWARS begins can be fully brought to bear on the training requirements of today's military force. These MOAs provide a foundation upon which we can work with DARWARS Program Management, other program participants and the MOA partners to form a concrete plan for moving forward with transition activities.

This document complements two other documents being delivered at the same time: an Architecture Design document that describes in detail the current status of DARWorld and our recommendations for further development, and a Developer's Guide that describes the services and interfaces developed for integrating training systems into DARWorld. These documents are deliverables at this point, and will be delivered again at the end of the project; we also intend to maintain regular updates on the project wiki at https://darwars.bbn.com/ to keep the documents in line with development.